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The credit rating process and estimation of transition probabilities: A Bayesian approach

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ABSTRACT

The Basel II Accord requires banks to establish rigorous statistical procedures for the estimation and validation of default and ratings transition probabilities. This raises great technical challenges when sufficient default data are not available, as is the case for low default portfolios. We develop a new model that describes the typical internal credit rating process used by banks. The model captures patterns of obligor heterogeneity and ratings migration dependence through unobserved systematic macroeconomic shocks. We describe a Bayesian hierarchical framework for model calibration from historical rating transition data, and show how the predictive performance of the model can be assessed, even with sparse event data. Finally, we analyze a rating transition data set from Standard and Poor's during 1981–2007. Our results have implications for the current Basel II policy debate on the magnitude of default probabilities assigned to low risk assets.

1. Introduction

The internal ratings based (IRB) approach in the New Basel Capital Accord (Basel II) allows banks to use their own internal credit ratings. Banks need to estimate the entire matrix of transition probabilities between rating classes, and the Accord stresses that these probabilities must play an essential role in the calculation of regulatory capital, credit approval, risk management, internal capital allocation, and corporate governance functions of banks (Basel Committee on Banking Supervision, 2006b). For regulatory purposes, the Accord requires financial institutions to establish rigorous procedures for the validation of statistical models for internal ratings (Basel Committee on Banking Supervision, 2005). These procedures include out-of-sample tests, and they must make use of historical data over as long a time period as possible.

These requirements present a great technical challenge for many financial institutions that have a large number of high quality business lines for which extensive default data are not available. Such low default portfolios typically include exposures to sovereigns, large corporations, or financial institutions such as banks (in developed nations) and insurance companies, where very few defaults have been observed over long horizons. The scale of the issue is significant—in a joint industry survey of seven UK

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firms having nearly US $3 trillion in total gross assets, over 50% of total wholesale exposures had insufficient default data (British Bankers' Association et al., 2004). Regulators expect that low default portfolios still follow minimum internal ratings based (IRB) standards for accuracy and conservatism of probabilities of default estimates, despite the data limitations. For low default portfolios, however, estimates of risk parameters based on simple historical averages or judgmental considerations alone, may underestimate capital requirements, raising the concern that financial institutions may not be able to apply the IRB approach for the many asset classes that have low number of defaults (British Bankers' Association et al., 2004).

There are two main technical challenges related to low-default portfolios. The first issue is the estimation of default probabilities when no historical defaults have been recorded. Hamilton et al. (2007, Exhibit 21) report that over the period 1980–2006 there are sixteen years when there were no defaults for investment grade issues. However, none of these assets is default free, hence any reasonable model should assign a positive default probability. The second technical challenge for low default portfolios is the assessment of a model's predictive performance. The usual out-of-sample testing procedures (Shumway, 2001) cannot easily be applied in this case, since the zero realized default frequencies do not constitute a reasonable benchmark against which to compare the model's predictions.

This paper addresses these issues and makes three contributions. Our first contribution consists in developing a new model that describes the typical credit rating process that most major banks employ. In general, an obligor is assigned a credit rating based on an assessment of its current credit worthiness, which depends on many systematic and firm specific variables. The model includes the effects of a shared unobserved macroeconomic shock which induces dependence among transition probabilities for different credit classes in any given period. The model specification also allows for auto-correlation across time of transition probabilities from any credit class. Lastly, the model takes into account the heterogeneity in the credit worthiness of obligors in the same credit class, which can have significant effects on credit risk diversification (Hanson et al., 2008). It is difficult to calibrate our model with data from low default portfolios in a classical frequentist estimation framework, because the sparsity of data often leads to unrealistic transition probabilities. Therefore, we use instead a Bayesian hierarchical framework for model calibration, based on Markov Chain Monte Carlo (MCMC) techniques. The MCMC approach produces the inferred distribution for all parameters of interest, including credible intervals for transition probabilities, and it thus allows users of the methodology to directly address regulators' concerns about out-of-sample model testing (Basel Committee on Banking Supervision, 2006a, §502). Within the Bayesian framework it is straightforward to model non-Markovian dynamics in ratings migrations, for which considerable empirical evidence exists (Altman and Kao, 1992a,b; Nickell et al., 2000; Bangia et al., 2002; Frydman and Schuermann, 2008). The Bayesian framework also offers a formal approach for taking into account expert opinion through the use of subjective prior distributions for the model parameters (Kiefer, 2007). This feature is important in the credit rating process where there is a large amount of non-quantifiable subjective information involved—senior credit risk officers often express opinions about the relative importance of certain inputs. Expert opinion gains even more weight in the case of low default portfolios, where there is a lack of objective historical transition data.

Our second contribution consists in addressing the difficult issue of assessing the predictive performance of a model when event data are sparse, such as is the case in low default portfolios. We employ two approaches to examine the predictive ability of a model. The first approach is based on a Bayesian measure of predictive power, the Deviance Information Criterion (DIC) developed by Spiegelhalter et al. (2002). When comparing the performance of several models, the model with the smallest DIC value is estimated to give the best predictions for a data set of the same structure as the data actually observed. The DIC measure has the advantage that it does not require the models to be nested for the purpose of comparison. Our second approach to investigating the predictive performance of a model is a variant of out-of-sample testing, taking into account not only the estimated transition probabilities but also the corresponding 95% credible intervals. For speculative grade classes where there is usually sufficient historical transition data, we compare observed default rates with the estimated default probabilities and their 95% credible intervals computed from the model. For investment grade classes where there are often no historical defaults, we can no longer use observed default rates as a benchmark. We thus compare instead the observed rates of staying in the same credit class with the estimated probabilities of no transitions and their 95% credible intervals computed from the model.

Our third contribution consists in applying our methodology to the analysis of an aggregate rating transitions data set from Standard and Poor's between 1981 and 2007, and deriving insights relevant for the current policy debate arising from Basel II. We calibrate different specifications of the credit rating process model and show that the estimated transition probabilities exhibit non-Markovian behavior, consistent with previous empirical evidence. We also find that the ratings transition matrix depends on the state of the economy, which can be partially described by two macroeconomic covariates—the return on the S&P 500 index and the Chicago Fed National Activities Index (CFNAI). As the CFNAI and S&P 500 return increase, the estimated default probabilities decrease for all credit classes as expected, and the effect of the macroeconomic conditions is generally larger for speculative grade than for investment grade classes. We find that the two macroeconomic variables, however, are not sufficient to capture the entire dynamics of the ratings transitions. The inclusion of a random unobserved macroeconomic shock significantly improves the predictive power of the credit rating process model, and at the same time accounts for the observed dependence among transition probabilities for different credit classes in any given period. We find that the estimated transition probability matrices are consistent with the monotonicity property, and that there is a potentially large heterogeneity among firms in the same credit class. We also find that the AAA rating class has very different dynamics than the other rating classes, and in particular that it is not sensitive to macroeconomic shocks. Finally, even in the absence of historical default data for top investment grade ratings, the credit rating process model always leads to positive estimated default probabilities in all credit classes, as required.